JOURNAL OF SEDIMENTARY PETROLOGY, VOL. 49, NO. 2, P. 0483–0486
FIGS. 1-3, JUNE, 1979

0022-4472/79/0049-0483/$03.00

X-RAY RADIOGRAPHY OF COAL[1]

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ABSTRACT: X-ray radiography reveals many compositional and textural differences that are overlooked by conventional procedures of coal analysis. Coals of all rank display a variety of organic and inorganic fabric elements that supply information on the sedimentological history of the peaty sediment, subsequent compaction, and authigenic mineral formation. This technique provides a detailed visual record that is well suited for studying lithotype variability.

INTRODUCTION

X-ray radiography has been shown by many researchers (Hamblin, 1962; Howard, 1969; Bouma, 1969; Roberts, 1972) to be a valuable technique for studying textural and compositional differences in sediments and consolidated rocks. Although widely used in sedimentological analysis, no reference has been found by the author concerning the application of X-ray radiography to coal petrology. It is a particularly useful technique for discerning fabric elements that define coal lithotypes.

PROCEDURE

The production of quality radiographs requires rock specimens prepared as thin (<4 mm) uniform slabs to minimize image blurring. Initial efforts to cut thin slabs of coal on a kerosene saw were unsatisfactory. The brittle and fractured nature of many rocks, including coal, cause slabs to crumble unless a backing of 4 mil acetate is applied after thoroughly wetting the cut surface with acetone (R. E. Larese, 1977, pers. comm.). Thin acetate sheets are suited for use as a backing material as they cover the sample uniformly and are transparent to X-rays at the voltage utilized. A slab thickness of 2 mm was chosen as a standard thickness for this study.

A Field Emission Corporation Faxatron 804 instrument with a 400-watt air-cooled tungsten tube was utilized. An X-ray source to specimen distance of 61 cm produced detailed radiographs. Kodak Type M film was used for its high resolution and short exposure time (see Faser and James, 1969, for a comparison of X-ray film characteristics.) A setting of 20 kV produced maximum specimen contrast. Positive prints were made on Kodak Rapid Polycontrast print paper.

An exposure chart (Fig. 1) was developed by cutting a wedge-shaped slab of bituminous coal ranging in thickness from 2 to 25 mm. The slab was radiographed at several exposure times. Optimum exposure was determined by subjectively viewing the negative and selecting the thickness which yielded the best apparent image. Fraser and James (1969) state that exposure guides may not be interchangeable among different radiographic instruments and film types, and it may be necessary for the researcher to develop different exposure times for his own radiographic instrument.

DISCUSSION

Coals ranging in rank from lignite to anthracite were radiographed (Fig. 2) and all revealed a variety of organic and inorganic fabric elements that could not be easily discerned by conventional techniques of coal analysis. Coal lithotypes are distinguished by the relative proportions of bright (vitrain) and dull (durain) bands which are readily visible on the radiograph. In the coals studied, vitrain bands correspond to light bands on the positive print while the duller durain

[1]Manuscript received August 30, 1978; revised December 1, 1978.

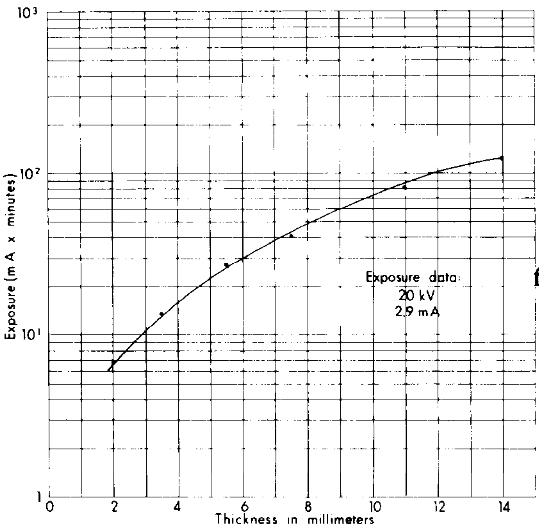
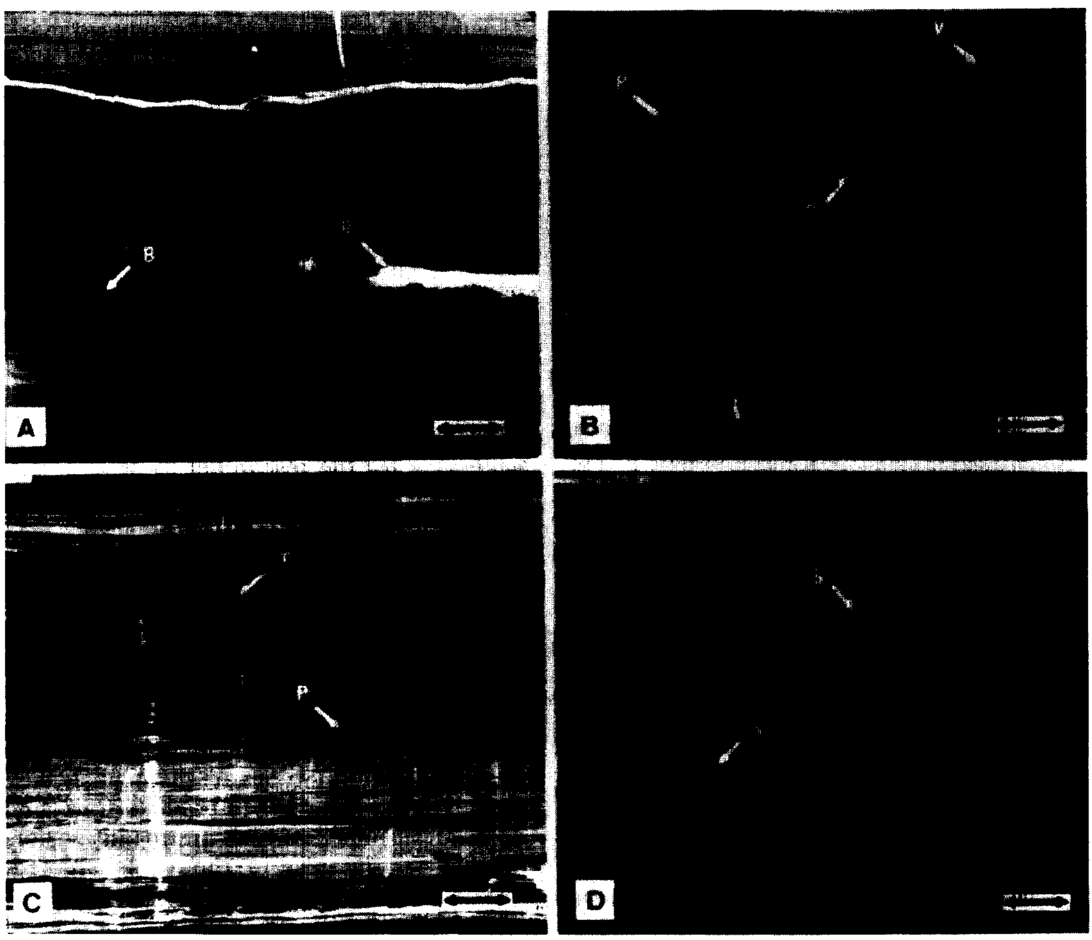


FIG. 1.-Plot of coal sample thickness verses milliamp minutes using Kodak Type M film.

bands in the coal correspond to darker bands on the positive print. At 20 kV admixtures of pyrite, quartz and clay minerals with organic matter increase the adsorption of X-rays. It is likely that the greater percentage of mineral matter in the durain bands causes them to appear darker, but maceral and porosity difference may also influence tone. Conventional techniques of lithotype classification using polished blocks are much slower than measuring the constituent bands in a positive print. If slabs of uniform thickness are prepared, instrumental image analysis techniques possibly could be utilized to determine the percentage of a given component based on its characteristic tonal element in the radiograph print.

Polished blocks, widely used in lithotype classication take much longer to prepare than radiograph slabs. A side by side comparison



of polished blocks and corresponding radiograph prints indicates that the visual detection of fabric elements such as the thickness, continuity, and distribution of vitrain bands is much easier in the radiograph print. Thin sectioning of coal is an arduous task and is impractical for large projects. Additionally, the optical assimilation and opacity of the macerals in medium-volatile bituminous and higher rank coals limits the application of transmitted and reflected light microscopy in these coals. Radiography reveals an enormous amount of textural and compositional information and is a saimple procedure for maintaining a detailed pictoral file (Fig. 3) of lithotype variability. The textural properties can be obtained quickly and inexpensively enough to provide a sufficiently large

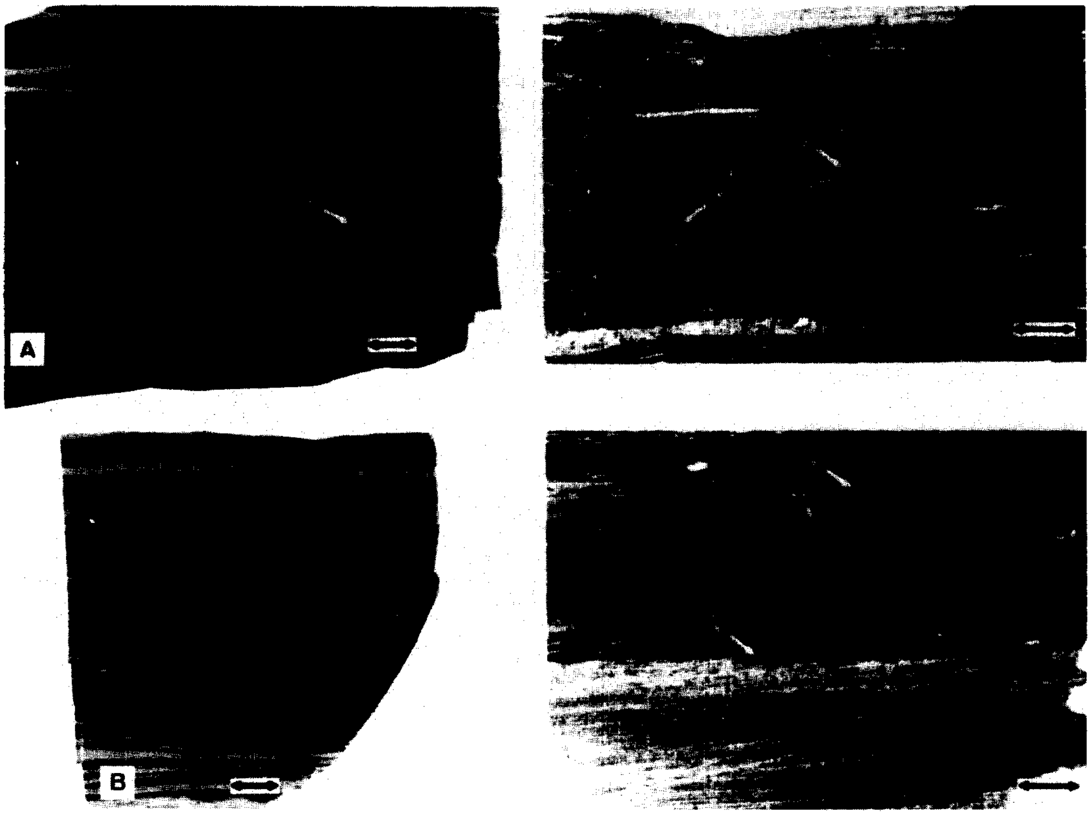


FIG. 3.—Fabric differences in two Lower Freeport coal samples collected from the same mine as revealed by radiographs and thin sections. Ash content of coal **A** is 6.8% with the mineral matter concentrated in cleats (F) or dispersed in a matrix (photomicrograph-right) of vitrinite shreds (V) and spores (S), giving the radiograph low tonal contrast. Coal B has an ash content of 8.8% with the mineral matter generally concentrated in darker laminae producing a pronounced banded fabric. Lighter bands in radiograph correspond to thicker homogenous vitrinitic layers (V) shown in photomicrograph. Scale bar is 1 cm in photomicrographs.

FIG. 2.-Radiographs illustrating fabric elements in coals of varying rank. A) Tertiary lignite with roots or branches (B) in a huminite rich matrix with varying admixtures of mineral matter producing darker tones. Large resin body (R) is transparent to X-rays. B) Pennsylvanian high-volatile bituminous coal showing greater degree of compaction than lignite with pronounced banded fabric defined by vitram (V) and durain (D) bands. Note difference in coal fabric above and below clay parting (P). Sub-vertical fractures are face cleats. C) Pennsylvanian low-volatile bituminous coal with numerous minor clay partings (P) and well developed face cleat system (F). Lighter-tone lower portion of sample contains less mineral matter. D) Pennsylvanian banded anthracite possessing numerous spherical mineral matter bodies (S) which are generally randomly distributed. Large vitrain band (V) is relatively mineral matter free and is likely a branch or root. Scale bar is 1 cm for all photos in this figure.

sample base to allow comparison with other parameters such as processing characteristics, mineral distribution, and sedimentologic history.

ACKNOWLEDGMENTS

This procedure was developed in connection with techniques derived from shale studies by U.S. DOE contract EY-76-C-05-5199. E. B. Nuhfer, M. T. Heald, and J. A. Sasso critically reviewed this manuscript. Jeff Clagett provided helpful advice on X-ray techniques. This paper was approved for publication by the Director of the West Virginia Geological and Economic Survey.

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